RAKSHAK (Soldier Assistance Vehicle)

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Abstract

An unmanned vehicle will assist the soldiers in performing several tasks during their route march. These tasks will include carrying stores and ammunition with approx payload weight of 200 kg. The unmanned vehicle (UV) will follow the battalion like a buddy. The unmanned vehicle can be manipulated with the help of a remote control base station with an additional feature of automated base returning. We have come up with the edging technique which will be compatible with cross-country mobility, autonomous following technique, localization, perception & path planning. Every possible method will be used to achieve the efficiency of the Unmanned Vehicle (UV). Different types of devices will be used in order to achieve the perfection of the Unmanned Vehicle (UV).The sensor’s working principle explained in the report applies on the RAKSHAK (SAV).

List of Abbreviations

SAV {Soldier Assistance Vehicle}

LiDAR {Light Detection and Ranging}

IMU {Inertial Measurement Unit}

GPS {Global Positional System}

UV {Unmanned Vehicle}

PID {Proportional Integral Derivative}

INS {Inertial Navigation System}

DMU {Dynamic Measurement Unit}

SLAM {Simultaneous Localization & Mapping}

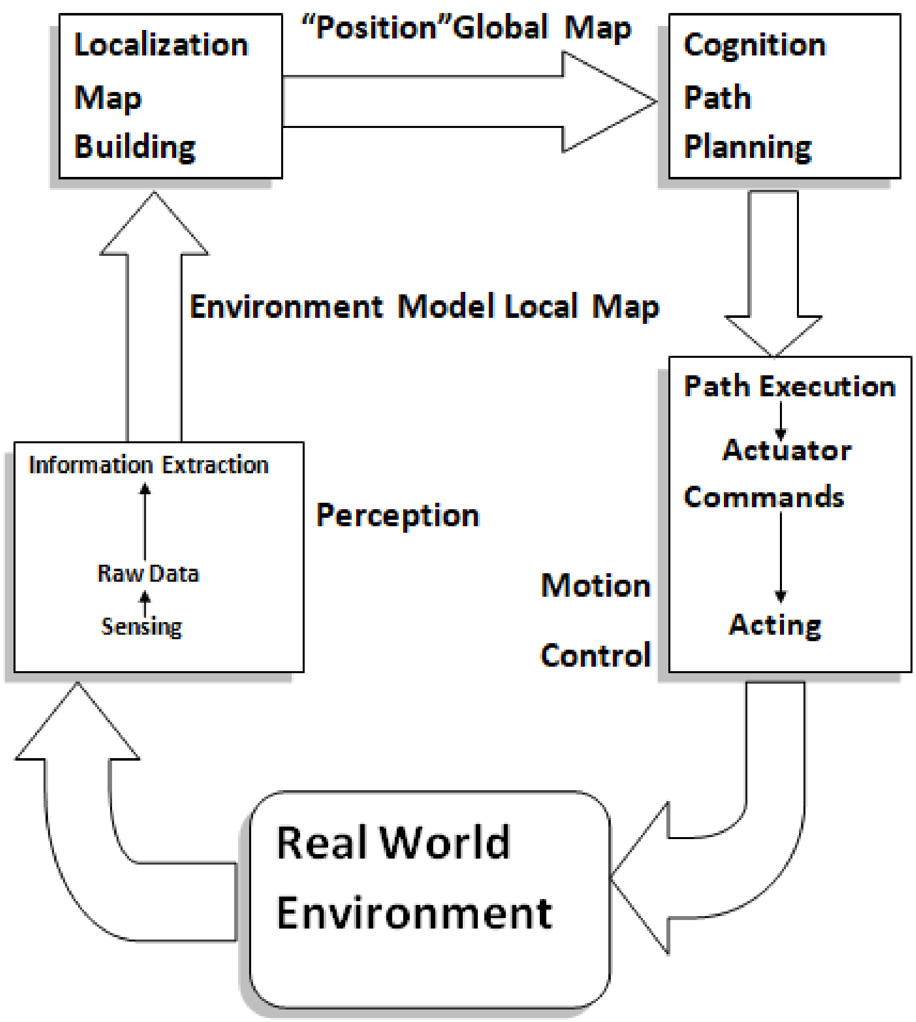
LPS {Local Positioning System}

Problem Statement

To assist soldiers in performing various tasks using unmanned vehicles (UV). The problem statement included certain criteria such as payload restriction of 200 Kg. To design a smart autonomous Soldier Assistance Vehicle (SAV) that can store and carry ammunition.

These obstacles will be tackled through modern technology. Mingling of software and hardware would result in the solution to the given problem statement.

Solution



In order to know the working of the UV, explanation of the block diagram is must.

The unmanned vehicle will feature the objects from real-world environment and will obtain the information, i.e. the Soldier Assistance Vehicle (SAV) will come up with the imaging of the present environment around it. This process will be obtained with High Definition (HD) camera. The camera will help in imaging the surrounding things within its accommodation range .Hence, creating the virtual map of the accommodated region.

The efficiency of the Unmanned Vehicle (UV) will come along with the use of different types of sensors. Now, the sensors such as infrared and ultrasonic sensors will be used in gathering the information from the real world environment.

Now, information gathered through the above usage of sensors will be a raw data for the Unmanned Vehicle (UV). The extraction of information will be made with the help of raw data; Unmanned Vehicle (UV) will be imaging the real world environment and extract the information as per need.
The information extracted from the sensors will be further manipulated by the Unmanned Vehicle (UV) for creating the local map.

As a localization map builder builds up the local map, this local map will be further connected or transformed to “position” global map where the whole regional map will be shown in order for execution.

These maps will help in producing the obstacle-free pathway for the Unmanned Vehicle (UV). As the cognition of the path is developed by the Unmanned Vehicle, further path execution will be done autonomously.

The motion control block will be handling the path trajectory as well as the speed of the bot, i.e. path execution comes along with actuator command. Finally, acting refers to the physical activity of the given command.

Proprioceptive Sensors

Wheel Encoders

Definition:

Electromechanical device that converts linear & angular position of a shaft to an analog or digital signal, making it an linear/angular transducer.

Working Principle:

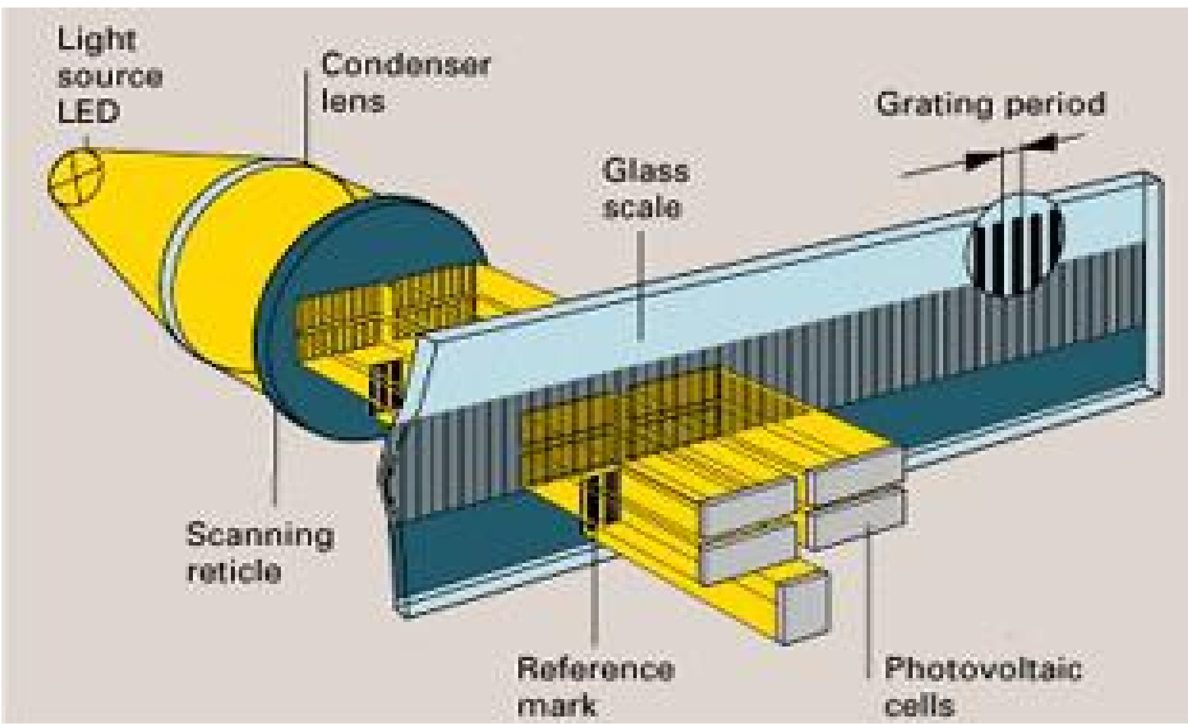
An optical encoder is an angular encoder sensor. It has a shaft mechanically coupled to an input driver which rotates a disc rigidly fixed to it. A succession of opaque and clear segments is marked on the surface of the disc.

Light from infrared emitting diodes reaches the infrared receivers through the transparent slits of the rotating disc. An analogue signal is created.

Then electronically, the signal is amplified and converted into digital form. This signal is then transmitted to the data processor.

<u>Used Cases</u>:

- Major position or speed of the wheels/stirring
- Integrated wheel movement to get an estimate of the position
- Based on principle of optical encoders

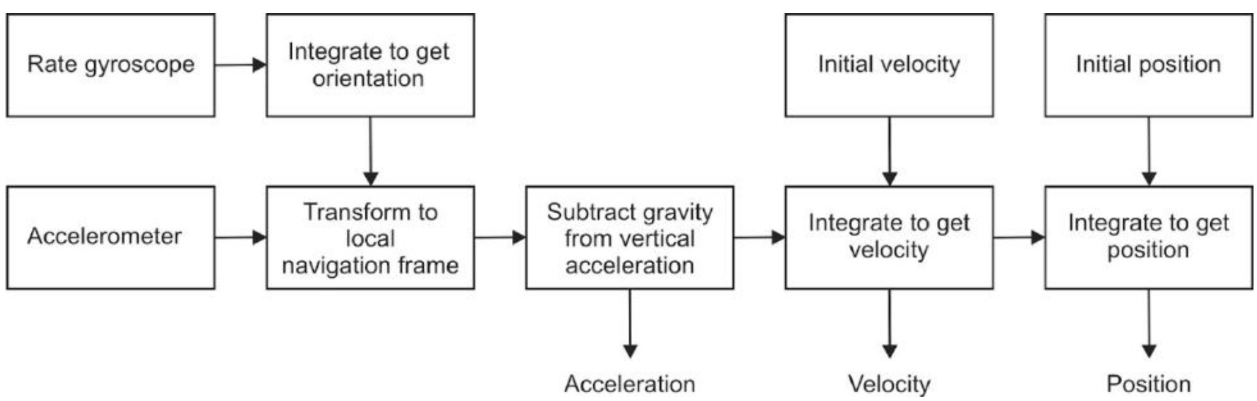


IMU (Inertial Measurement Unit)

Definition:

An inertial measurement unit (IMU) is a device that uses measurement systems such as gyroscopes and accelerometers to estimate the relative position (x, y, and z), orientation (roll, pitch, and yaw), velocity, and acceleration of a moving vehicle with respect to an inertial frame.

Working:



Use Cases:

To estimate the position, velocity and acceleration of RAKSHAK (SAV).

Global Positioning System (GPS)

Definition:

GPS is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Working Principle:

Location of any GPS receiver is determined through a time of flight measurement (satellites send orbital location (ephemeris) plus time); the receiver computes its location through trilateration and time correction.

Differential GPS:

DGPS requires that a GPS receiver, known as the base station, be set up on a precisely known location. The base station receiver calculates its position based on satellite signals and compares this location to the known location. The difference is applied to the GPS data recorded by the roving GPS receiver position accuracies in sub-meter to cm range.

Exteroceptive Sensors

Light Detection and Ranging (LiDAR)

Definition:

A surveying method that measures distance to a target by illuminating the target with pulsed laser light and measures the reflected pulses with a sensor.

Differences in laser return times and wavelengths can then be used to make digital 3-D representations of the target.

Working Principle:

Pulsed laser measurement of elapsed time directly resolving picoseconds.

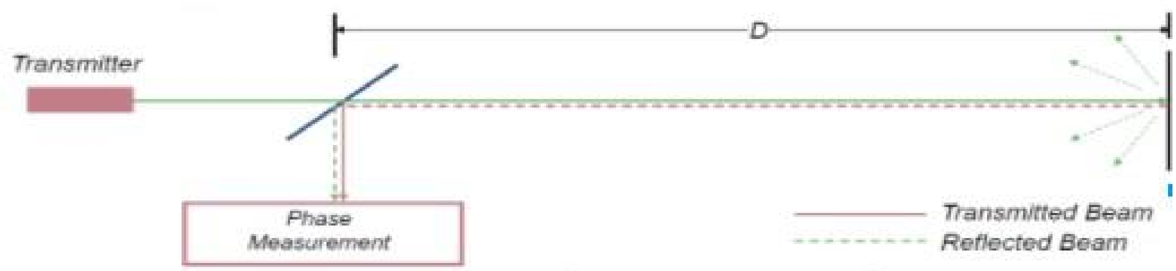
Pulse laser
Range distance (R) and range resolution (ΔR)

$$R = c\frac{t}{2} \qquad \Delta R = c\frac{\Delta t}{2}$$

where:
c: speed of light (~299,792,458 meters/second)
t: time interval between sending/receiving the pulse (ns)
Δt: resolution of time measurement (ns)

Phase shift measurement to produce range estimation technically easier than the above method.

- *Phase-Shift Measurement*

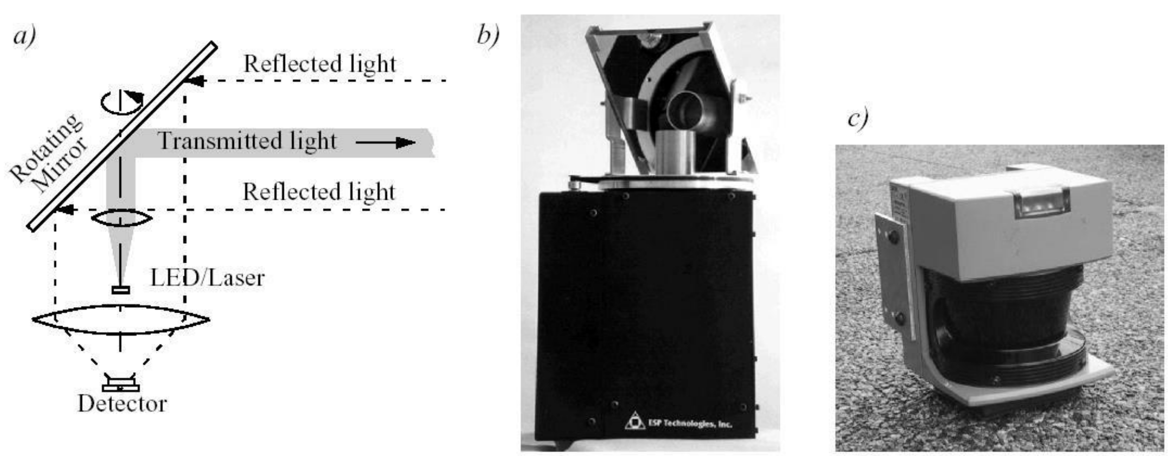


$$D' = 2D = \frac{\theta}{2\pi}\lambda \qquad \lambda = \frac{c}{f}$$

Where:

c: is the speed of light; *f* the modulating frequency; *D'* the distance covered by the emitted light.

- for f = 5 MHz (as in the A.T&T. sensor), λ = 60 meters



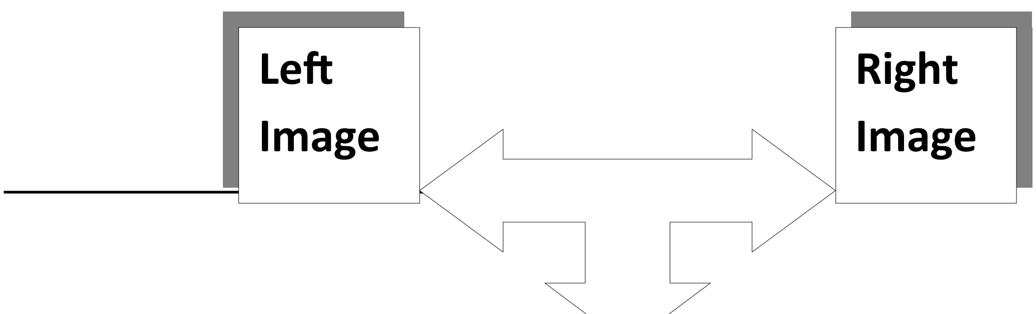
Use Cases:

It is used for 3D representation. The orientation and position is used for mapping the external environment.

Stereo Vision

Definition:

A way of calculating the depth with the help of image creating a 3rd dimensional; height from 2-D images.

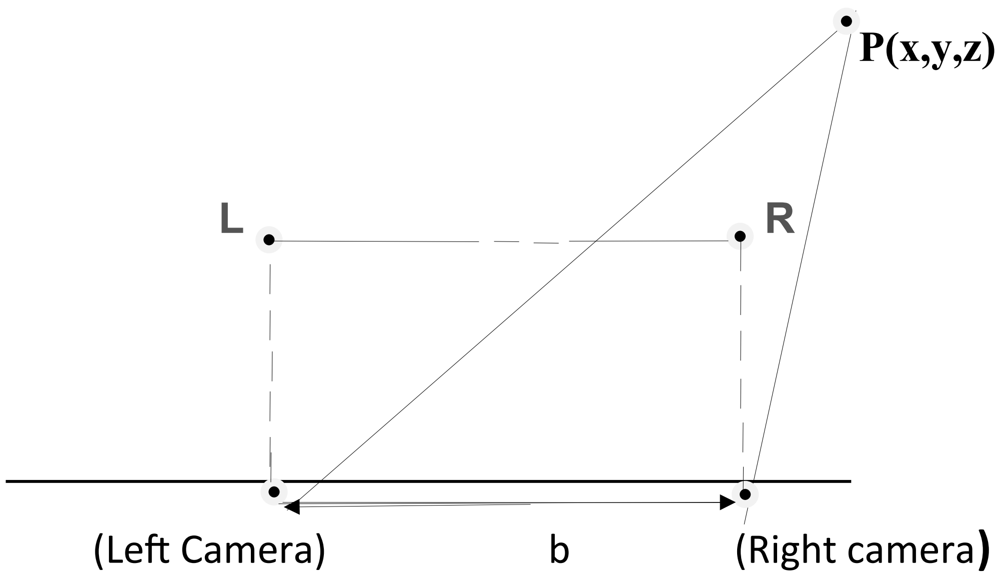


[Surface geometry can be formed]

Working:

Requires two cameras.
Assume image planar and coplanar.
There is only translation in the X-direction between the two co-ordinate frames. b is the baseline between the cameras.
Disparity is the horizontal shift between the two camera images.

$$\boxed{Z = (f*b)/d}$$



Z = depth of the image
f = focal length;
b = baseline b/w 2 cameras
d = disparity [L-R]

Ultrasonic Range Sensors

Definition & Working:

It's a type of a sensor use to measure the distance with the help of piezoelectric emitter and receiver. Based on the speed of sound in air and the elapsed time from emission to reception, the distance b/w the sensor & the object easily calculated.

Useful in short and long range (12cm to 5m).

RAKSHAK accuracy of measuring the distance would increase drastically with the decrease in error.